## ➢Example (1)

Three identical coils, each having a resistance of 20 Ω and an inductance of 0.5 H connected in (a) star and (b) delta to a three phase supply of 400 V; 50 Hz. Calculate the current and the total power absorbed by both method of connections

## ➢Example (1)

Three identical coils, each having a resistance of 20 Ω and an inductance of 0.5 H connected in (a) star and (b) delta to a three phase supply of 400 V; 50 Hz. Calculate the current and the total power absorbed by both method of connections

- First of all calculating the impedance of the coils

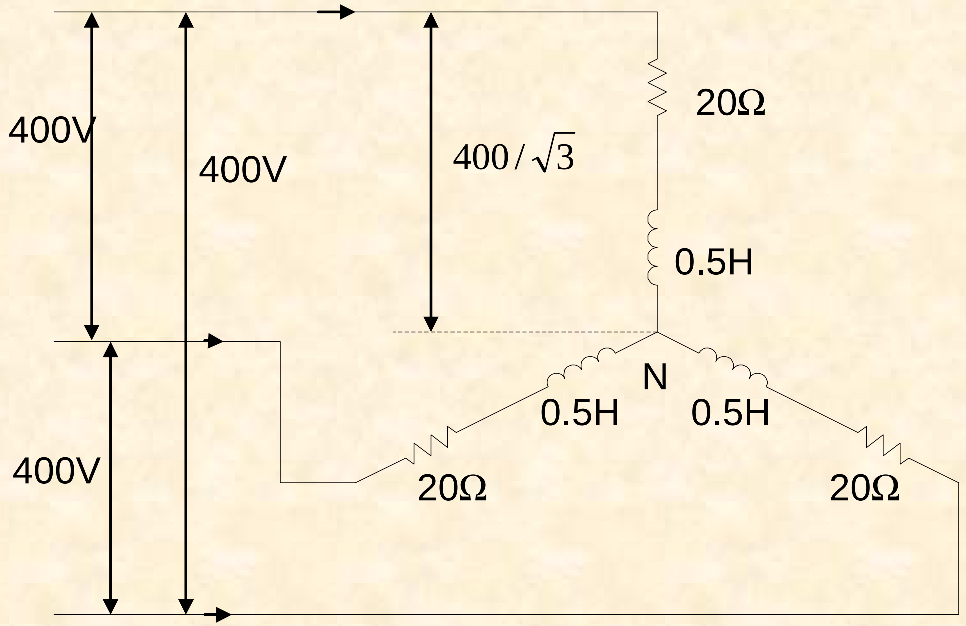
$$R_\phi = 20\Omega \qquad X_\phi = 2\pi \times 50 \times 0.5 = 157\Omega$$

$$Z_\phi = R_\phi + jX_\phi = \sqrt{R_\phi^{\ 2} + X_\phi^{\ 2}}\angle\theta \qquad \text{where} \qquad \theta = \tan^{-1}\left(\frac{X_\phi}{R_\phi}\right)$$

$$= \sqrt{20^2 + 157^2}\angle\tan^{-1}\left(\frac{157}{20}\right) = 158\angle 83^\circ$$

$$\cos\theta = \cos 83^\circ = 0.1264$$

## ❑ Y-connection



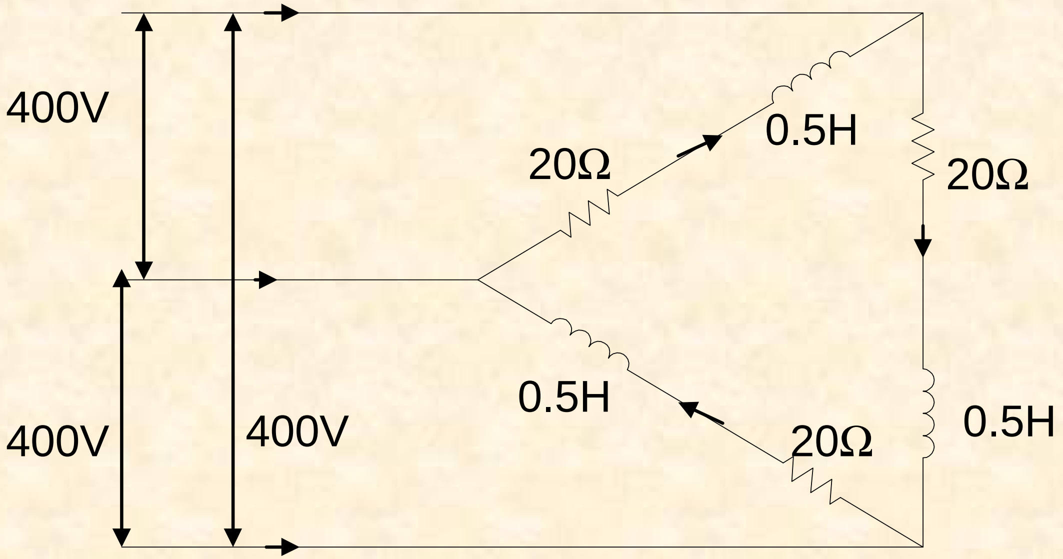

- Since it is a balanced load

$$V_\phi = \frac{400}{\sqrt{3}} = 231V \qquad I_\phi = I_L = \frac{V_\phi}{Z_\phi} = \frac{231}{158} = 1.46A$$

- Power absorbed

$$P = \sqrt{3}V_L I_L \cos\theta \quad = \sqrt{3} \times 400 \times 1.46 \times 0.1264 = 128\text{W}$$

## ❑ Δ-connection




$$V_{\phi} = V_L = 400V$$

$$I_{\phi} = \frac{V_{\phi}}{Z_{\phi}} = \frac{400}{158} = 2.532A$$

$$I_L = \sqrt{3} I_{\phi} = 4.385$$

$$P = \sqrt{3} V_L I_L \cos\theta \qquad = \sqrt{3} \times 400 \times 4.38 \times 0.1264 = 384W$$

## ➢Example (2)

A balanced three-phase system with a line voltage of 300V is supplying a balanced Y-connected load with 1200W at a leading power factor (PF) of 0.8. Determine line current $I_L$ and per-phase load impedance $Z_\phi$

## ➢Example (2)

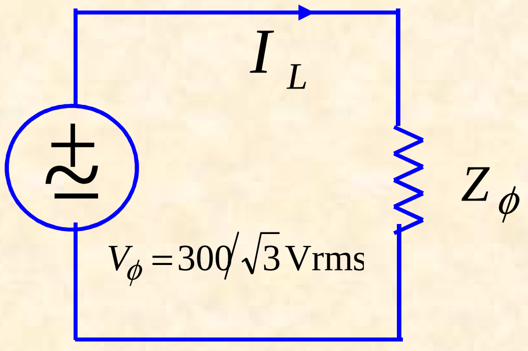
A balanced three-phase system with a line voltage of 300V is supplying a balanced Y-connected load with 1200W at a leading power factor (PF) of 0.8. Determine line current $I_L$ and per-phase load impedance $Z_\phi$

The phase voltage is: $V_\phi = 300/\sqrt{3}$ V

The per-phase power is: 1200W/3 = 400 W

Therefore $400 = \dfrac{300}{\sqrt{3}}(I_L) \times 0.8$ , and $I_L$ = 2.89 A

The phase impedance is: $|Z_\phi| = \dfrac{V_\phi}{I_L} = \dfrac{300\sqrt{3}}{2.89} = 60\Omega$




A leading PF of 0.8 implies the current leads the voltage, and the impedance angle is: -argcos(0.8) = -36.87$^o$

and $Z_\phi = 60\angle -36.87^o\ \Omega$

Note: the <u>per-phase</u> apparent power of a Y-Y connected load is $\boldsymbol{P = V_{an} \times I_{aA}}$

**<u>(phase voltage × line current)</u>**

## ➢Example (3)

Determine the amplitude of line current in a three-phase system with a line voltage of 300V that supplies 1200W to a $\Delta$-connected load at a lagging PF of 0.8

## ➢Example (3)

Determine the amplitude of line current in a three-phase system with a line voltage of 300V that supplies 1200W to a Δ-connected load at a lagging PF of 0.8

The per-phase average power is: 1200W/3 = 400W

Therefore, 400W = $V_L \cdot I_\phi \cdot 0.8 = 300\text{V} \cdot I_\phi \cdot 0.8$, and $I_\phi = 1.667\text{A}$

The line current is : $I_L = \sqrt{3}\, I_\phi = \sqrt{3}\ 1.667\text{A} = 2.89\text{A}$

Moreover, a lagging PF implies the voltage leads the current by argcos(0.8) = 36.9°

The impedance is: $$Z_\phi = \frac{\dot{V}_\phi}{\dot{I}_\phi} = \frac{300}{1.667}\angle 36.87^o = 180\angle 36.87^o\ \Omega$$

Note: the per-phase apparent power of a Δ-connected load is $\boldsymbol{P = V_{AB} \times I_{AB}}$

**(line voltage × phase current)**

# Power System Loads

- **Single-phase power**
  - Residential and business customers
- **Single-phase and three-phase systems**
  - Industrial customers
  - Therefore, there is a need to connect both single-phase and three-phase loads to three-phase systems
- **Utility tries to connect one third of its single-phase loads to each phase**
- Three-phase loads are generally balanced

# Power System Loads

## ❑ Real loads

– Seldom expressed in terms of resistance, capacitance, and inductance

– Rather, real loads are described in terms of power, power factors, etc.

# Measuring Power in Three-Phase Circuits

- **Measuring power to a 4-wire Y load requires three wattmeters (one meter per phase)**

✓ Loads may be balanced or unbalanced

✓ Total power is sum of individual powers

✓ If load could be guaranteed to be balanced

- Only one meter would be required
- Its value multiplied by 3

# Measuring Power in Three-Phase Circuits

- **For a three-wire system,** only two meters are needed
  - Loads may be Y- or Δ-connected
  - Loads may be balanced or unbalanced
  - Total power is algebraic sum of meter readings